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Using Data Visualization in Creativity Workshops: A New Tool in the Designer's Kit

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ABSTRACT
Creativity workshops have proved effective in drawing out unexpected requirements and giving form to participants' novel ideas. Here, we introduce a new addition to the workshop designer's toolkit: interactive data visualization, used as stimuli to prompt insight and inspire creativity. We first describe a pilot study in which we compare the effectiveness of two different styles of data visualization. Here we found that a less ambiguous style was more effective in supporting idea generation. Following this, we report a case study in which we employ data visualization within a service design workshop, where participants use it to gain insights that are later realized in design ideas.

Author Keywords
Creativity support, workshop techniques, data visualization

ACM Classification Keywords
H.5.m Information Interfaces and Presentation (e.g., HCI): Miscellaneous

INTRODUCTION
In recent years, generative co-design and creativity workshop techniques have become increasingly familiar. Their effectiveness has been demonstrated during requirements gathering for socio-technical systems [11] and in early stage design research [14]. In this paper we propose a new addition to the workshop designer's toolkit: interactive data visualization. We do so in order to take advantage of the data that result from the increasing ubiquity of computing systems [1]. This data offers a wealth of domain relevant information that could be an important resource for design.

First, we outline a pilot study in which two styles of data visualization were compared to investigate whether the clear and explicit representation of data values, cited as important in the information visualization literature [2,7], runs counter to the tolerance of ambiguity, identified as having a positive impact on ideational fluidity in creativity studies [10]. Following this we report on a case study, undertaken with the support of E.ON Energy, in which our techniques are applied during a workshop investigating service design with data generated by smart homes.

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RELATED WORK

Design Workshops
The research presented in this paper builds on the previous work of one of its authors [11]. Here, representatives of key stakeholder groups participate in a range of workshop activities including the use of creativity triggers, analogical reasoning, constraint removal and storyboarding in order to generate novel and useful ideas that can be translated into requirements for future systems. Similarly, Sanders [14] has shown the effectiveness of generative co-creation workshops in early stage design. Here, participants use toolkits made up of a large number of ambiguous stimuli to create artifacts expressing their design ideas. We build on these approaches by using data visualization to support participants' exploration of domain relevant information. We combine this visual exploration of data with generative creativity activities designed to encourage consideration of the wider context from which the data is taken. Our aim is to support participants seeking insight into existing practice.

Data Visualization
In using the term data visualization we are referring to the graphical representation of information, data or concepts. The examples of data visualization outlined in this paper are all interactive. Information visualization has been identified as a transformational tool to support creativity [15]. In this paper we describe how it is used to support the creativity of participants in design workshops. The data visualizations we use must reflect the collaborative, relaxed setting we try to foster workshops. In this respect, the work of Wattenberg and Kriss [17] exploring *social data analysis*, and in particular their discussion of *expressive spectator interfaces* is influential. So too are Pousman, Stasko and Mateas [13] who introduce us to *casual information visualization*. The distinctions they draw between four different types of insight are particularly helpful.

PILOT STUDY

Introduction
Tolerance of ambiguity has been identified as a key component in the psychology of creativity since the foundational research of Guilford [10]. Gaver, Beaver and Benford [8] note its usefulness as a resource in interaction design and Sanders [14] its role in promoting creativity in

design workshops. Conversely, ambiguity is commonly seen as something to be avoided or reduced when visualizing quantitative data [2,7]. We wanted to see if this requirement for clarity and explicitness when representing data values, ran counter to the ideational possibilities offered by ambiguity.

Pilot Study Methods

We held a series of four workshops where the objective was to suggest ideas for new products or services utilizing the data generated by smart home energy technology. In each workshop, participants undertook one round of activities with a data visualization designed to heighten ambiguity and another round with a data visualization designed with ambiguity reduced. The order in which participants used the different styles of data visualization was varied to reduce ordering and priming effects.

Data Visualizations

The two data visualizations used in this study were based on data from a trial of smart home technologies E.ON Energy are conducting in Milton Keynes, UK. Each data visualization shows the total electricity consumption and the consumption of eight individual appliances for each of the twenty-four hours, on each of the seven days of a single week. This data can be displayed as consumption in kilowatt-hours or as a cost, measured in pounds sterling. Each day's consumption is represented in five separate price bands. Such variable pricing has been identified as one possible future direction for energy tariffs. The more ambiguous visualization is shown as a screenshot in Figure 1 and is available in its interactive form online[1]. The less ambiguous style of visualization is shown as a screenshot in Figure 2 and is available in its interactive form online[2].

Participants

Each workshop had three participants, post-graduate students and staff from City University London's schools of Informatics and Engineering. There was a mix of seven female and five male participants aged between 25 and 54. Participants were not selected for their domain expertise.

Workshop Activities

Control has been identified as a key smart home concept by E.ON. In the first activity, participants were asked to brainstorm ideas for things or people who exert control. In the second activity, participants worked collaboratively exploring the first data visualization and noting individual observations of important or interesting things. To encourage insight seeking participants were asked to consider five prompts: *'What do you see?' 'What do you think it is for?' 'What are you thinking whilst you explore?' 'What do you notice in the visualization?' 'What story does it tell?'*. At the end of this activity, participants collated and shared their observations, which were then put on display.

[1] [1] http://grahamdove.com/eon/ambiguous.html

[2] [2] http://grahamdove.com/eon/unambiguous.html

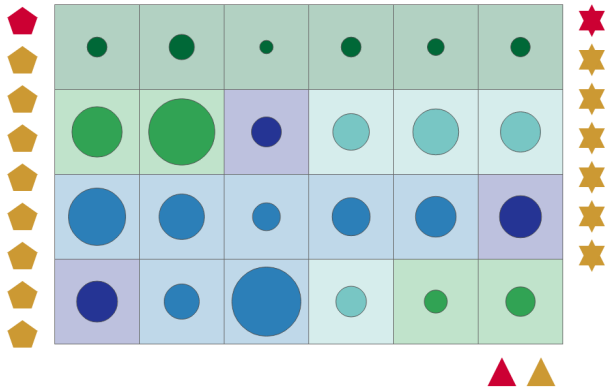

Figure 1. More Ambiguous Visualization Style

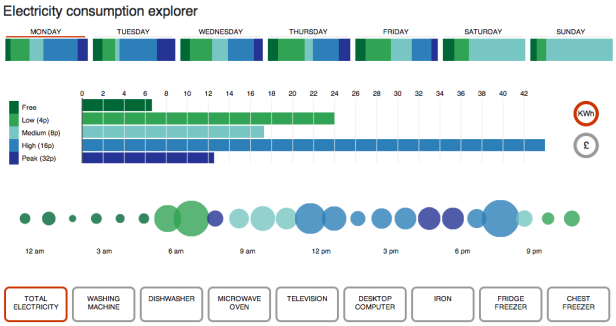

Figure 2. Less Ambiguous Visualization Style

In the third activity, participants worked individually. Examples from the first activity were combined with insights from the second to generate ideas for innovative products or service, using a wishful thinking technique. The fourth activity was a repeat of the second but those who had previously seen the more ambiguous data visualization were now given the less ambiguous version and vice versa. The fifth activity repeated the third, this time combining outputs from the first activity with insights from the fourth.

Data Collection and Analysis

The outputs from the second and fourth activities were analyzed to assess support for insight discovery. These were grouped by type, using thirteen categories. The ideas generated in the third and fifth activities were counted and assessed for novelty and appropriateness by independent domain experts as a measure of creative output [4]. Further evaluation data came from a questionnaire participants completed at the end of each workshop condition. This was derived in part from the Creativity Support Index [3] and in part from discussion of insight in the visualization literature [12,18]. Finally, observer notes and video recordings of each workshop were analyzed.

Pilot Study Findings

The key finding from our pilot study was that the less ambiguous style of data visualization provided more effective support to participants. Not only were they better able to explore the underlying data and gain insight, but they were also more likely to discuss factors from the wider

context not directly shown, such as possible lifestyle choices of the household they thought might have been using the energy. This study is discussed in more detail elsewhere [5].

CASE STUDY: E.ON ENERGY DESIGN WORKSHOP

Background

This case study describes a one-day creativity workshop held in Milton Keynes, UK, and which is part of a larger research project, funded by E.ON International Research Initiative investigating the use of data visualization tools to engage creatively with energy data. The objective of this workshop was to outline ideas for new services that utilize the data generated by smart home technologies.

Data Visualization

The interactive data visualization employed in this workshop was based on the less ambiguous style from our pilot study. It was updated to reflect feedback we received from participants and input from data visualization experts. The visualization is based on data generated by a model of typical energy consumption developed by partners in the project [9], and represents one week's energy consumption for a possible household. Screenshots of the data visualization are shown in Figure 3 and Figure 4, it is available in its interactive form online[3].

Participants

There were ten male and three female participants, two were E.ON staff and eleven customers recruited from a long-term technology trial E.ON are undertaking. Their ages ranged from teen-age to pensioner. All participants were familiar with energy monitoring and smart home data, and had experience with visualizations of energy data through their smart home monitors. Participants self-allocated into one of four groups.

Workshop Activities

Each group was given a toolkit consisting of marker pens, post-it notes, colored paper shapes, glue, tape, scissors and around three hundred photographs split into categorized envelopes containing people, buildings, transport, food and technology. The visualization was presented to the workshop participants using iPads.

Activity 1: Personas In their groups, participants used insights gained from the data visualization to help them describe the type of household it might represent. They realized this imagined household by making a collage on an A1 worksheet. Here they were given prompts to explore the lifestyle and context surrounding energy consumption. These included asking them to picture the household and the property; how they might feel about technology, their mealtimes and the ways they might travel.

Activity 2: Preparation Again in groups, participants explored the data visualization to uncover smarter ways their imagined household might use energy. This could be either by reducing the total amount of energy used or reducing their energy bill through responding to the variable pricing bands. Their top five ways to be smarter with energy were entered into a competition entry form together with their response to a tiebreaker asking them to briefly describe the piece of smart home technology, either real or imaginary, that would most improve their imagined household's lives.

Activity 3: Reflection Participants individually completed a set of three reflective postcards to provide evaluation feedback.

Activity 4: Brainstorm In a single large group, participants undertook a three-stage brainstorm. Ideas for different types of data a smart home may generate and for products or services that might utilize this data were suggested before their emotional responses to these ideas were captured.

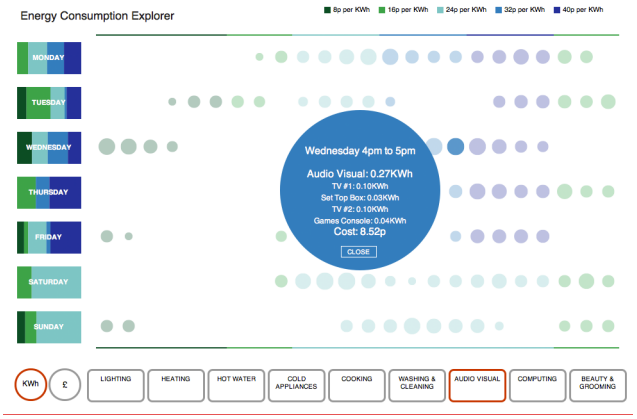

Figure 3. Hourly Consumption Detailed View

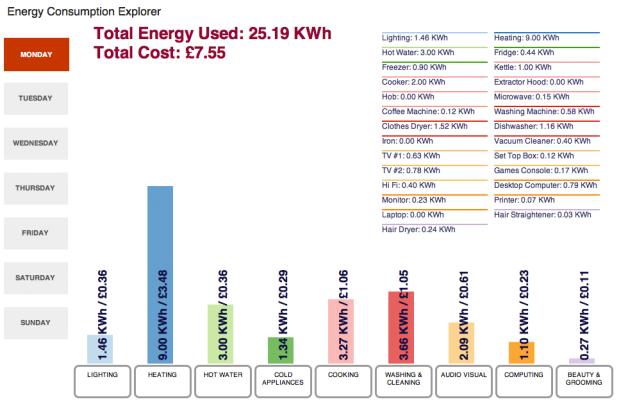

Figure 4. Daily Consumption View

Activity 5: Service Design In their small groups participants created a storyboard describing their service at three key stages: point of sign-up, when it used for the first time, and once it had become an accepted and regular part of their household's life.

[3] [3] http://grahamdove.com/eon/index.html

Data Collection and Analysis

To evaluate participants' self-reported perceptions of the effect the data visualizations had had on their creative activities, we designed Activity 3 in which they completed three reflective postcards. This is discussed in more detail elsewhere [6]. In addition, the outputs from the first two activities, in which the data visualization played a central role, were analyzed for evidence that participants gained insights, explored alternative options and created rich descriptions of their imagined households. These would contain numerous details about the background of the imagined household and the context of their energy use. The final service design outputs were analyzed for evidence of an identifiable path, traced from insights gained in data exploration, through to their application in design ideas.

Workshop Findings

Our analysis indicates that participants felt engaged and easily able to collaborate whilst using the data visualization, they felt able to build on their existing knowledge and that there was strong support for participants gaining insight, with both overview, and patterns and relationships being easy to discover. The outputs from the first two activities showed evidence that insights gained from the data could be used to inspire imaginative responses that reflected the participants' wider experiences. Analysis of the final service designs indicates that these insights and the ideas they prompted had played a significant role. These indicate that using the data visualization prompted participants to seek domain relevant insight in an engaging way. They also show that these insights could be developed to support the creativity in participants' prototype service designs. This case study is discussed in more detail elsewhere [5].

DISCUSSION AND FUTURE WORK

In this paper we have begun to demonstrate how interactive data visualization can be a powerful addition to the workshop toolkit. In our pilot study we discovered that clarity and explicitness does not run counter to the ideational fluency that has been associated with ambiguity, and in our case study we discovered that participants can gain insights from data visualizations during workshop activities before realizing them in design ideas. Our research appears promising and we now need to replicate our findings in other domains and using different types of data.

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